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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

PROGRESS REPORT -- SPRAYING WITH LETHAL OIL TO CONTROL THE MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

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Forest Insect Laboratory
Coeur d'Alene, Idaho
Jan. 22, 1938

Dr. F. C. Craighead
Washington
D. C.

Dear Dr. Craighead:

There are enclosed two copies of Mr. Gibson's progress report on the penetrating oil studies. Obviously, we should be very pleased to have your very frank comments on this report. This season we encountered field conditions which required rather severe adjustments of our plans. After arriving in the field we found that, in the area previously selected as containing normally attacked trees, there had been such a heavy mortality in the overwintering broods that very few insects could be found above a height of 4 or 5 feet on the bole. Though below this point there were living insects on some trees, the broods were not very heavy. To meet this condition we treated the lower four feet on the north side of all trees, using the south side as a control of each treatment. Laths were nailed on the east and west sides of the trees as a mark of the boundary of the treated portion.

Plans for the subsequent examination of these trees call for the taking of the regulation quarter- or half-square-foot sample with the customary intensive brood data. As the broods were so light and as quite often there would be only one or two insects encountered in a quarter-square-foot sample, it was obvious that the finding of one living insect on the treated portion might and did completely reverse the actual status of results obtained. It was therefore necessary to add to the one-quarter-square-foot intensive sample a more general sampling, which consisted of the removal of sufficient bark to satisfy the examiner as to the status of the broods on both the treated and untreated portions of the trees. Full and complete notes were taken of each extensive examination.

The presentation of the information secured from these extensive examinations was somewhat of a problem. After testing several methods it was decided that the best procedure would be a brief summary of the results from each tree. Though this resulted in a rather voluminous series of tabulations, we believe that it has very accurately depicted the findings secured.

We are quite encouraged over the results secured from this potential method of control and believe that they indicate the feasibility of its adoption as a standard practice. However, before it could be adapted to practice we believe that some further improvements, especially in the question of equipment, are necessary. We hope to be able to work on this phase of the subject during the coming season. I am going to write you in a few days concerning a potential location for this season's experiments.

Respectfully yours,

James C. Evenden
Entomologist

cc to:
Mr. Miller
Mr. Keen
Mr. Beal

PROGRESS REPORT -- SPRAYING WITH LETHAL OIL TO CONTROL THE MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

Introduction

A major objective of the Division of Forest Insects is the formulation of new and the improvement of existing methods of control for insects injurious to forest trees. In search of a better method of control for the western pine beetle attacking ponderosa pine, the personnel of the California station experimented with lethal oils. The method consisted of mixing or dissolving in a penetrating oil a material lethal to the insects and spraying it upon the infested tree. The oil carries the lethal material through the bark until it is in contact with the infesting brood. In spite of the thick bark on the ponderosa pine, some success was reported. It was believed even better results might be obtained with the mountain-pine-beetle-infested lodgepole pine because of its thin bark and despite its growth in a region of lower maximum temperatures, so the California station was requested to allow the more promising materials to be tested by the Coeur d'Alene station personnel. High air temperature is believed to aid materially in securing a rapid penetration through the bark and consequent effectiveness of the oils, while lower temperatures are thought to retard penetration and favor loss of both oil and lethal material through evaporation, thus decreasing its effectiveness.

Previous Tests

A preliminary test made with one oil on the Beaverhead Forest in 1934 was attended with sufficient success to justify continuation of the experiment. Early in the summer of 1935 the experiments were continued in an area near Antelope Flat on the Targhee Forest which was being devastated by a mountain pine beetle infestation in lodgepole pine. Thirty-three trees treated with three different oils gave fairly good control and a basis for comparing the effectiveness of the oils.

The possibilities of fall control were tested by spraying a few trees in October of 1935, and examining them the following spring. The control obtained was quite encouraging, sufficiently so to indicate that fall control may be feasible.

From the results obtained in 1935 and 1936 the oils which contained orthene, or a combination of orthene and naphthalene, gave the best results, but the hoped-for 100 percent control was not obtained. Survival was chiefly at the base where the bark was thick or green, but occasional brood was also present in the sprayed portion above that height. Above the base of the tree the reasons for survival are not clear, but where thick bark does not protect the insects, insufficient spraying is believed to be the cause.

Experiments Conducted in 1937

In 1937 experiments with the oils that had given the best results

in 1935 and 1936 were continued as well as with other materials offering promise of giving good control.

Trees selected for the experiments covered as representative a set of conditions as possible for the locality. Another requirement of the trees selected was ample brood to at least 6 feet, as indicated from examination under small areas of bark on portions of the trees that were not to be treated. Owing to the variability in brood conditions which have been observed in different groups of trees attacked by the mountain pine beetle, a proportionate number of trees were treated with each material in each group. This arrangement, together with the light infestation, resulted in the scattering of trees for each treatment over considerable area. Sufficient trees were also left untreated in each group to serve as checks or controls for the treated trees.

Treating the Trees

For the purpose of the experiment, the treating of one-half of the bark surface of a tree to a height of four feet was considered sufficient. The north half of the tree was the part selected, as the small amount of sunlight received by that portion was believed to represent the most difficult test of the treatment. As has been previously mentioned, sunlight is thought to materially increase the effectiveness of lethal oils. Only a sufficient number were sprayed on the south side to observe any unforeseen effects that spraying on that side might show.

Examination of the Trees

In examining the treated trees one or more 1/4 square foot samples of both the treated and untreated sides, supplemented by extensive examinations, were made in order to be more certain of the effectiveness of the treatments. Examination of so much surface was necessary because of the comparatively light brood present in the trees this season.

Check trees were given two examinations--the first on June 15 during the period when most of the spraying was being conducted, and again in July when the treated trees were examined. The two examinations were made not only to give an indication of brood status at the time of spraying and of examining the treated trees, but to furnish data on normal brood mortality during the interval between these two periods.

TREATMENTS IN 1937

Formula A

This formula consisted of the following materials:

Light stove oil	--- 3 parts
Heavy stove oil	--- 1 part
Orthene	--- 1 part
Naphthalene	--- 3/4 lb. per gallon of oil

The preceding formula was given the most exhaustive test because of the promising results during previous years. Fifteen trees were treated on June 10; 15 more on June 16; 15 on the 23rd; and 10 on July 6, the successive treatments having for their objective the determining of the period during which effective control can be secured. The data from the intensive and extensive examinations are given in table I under subheadings for the date sprayed.

Table I

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 10, 1937 -- FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
15	36.2	100	-	-	1.2	10.9	9.8	89.1

Notes from Extensive Examination

Tree No.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
163	Med.	Med.	3 living larvae under green patch -- 100% mortality elsewhere	Only normal mortality
164	Heavy	Med.	1 living larva -- no apparent reason for its survival	Only normal mortality to medium living brood of larvae, pupae, and new adults
165	Med.	Light	Large number of dead brood in intensive sample due to sample variation -- 100% control	Only normal mortality to light brood of pupae and new adults. Large number of dead brood again due to sample variation.
166	Light	Med.	All brood killed under 8 sq.ft. of bark except 2 pupae from under a thick patch	Brood of pupae and new adults showed only normal mortality
167	Med.	Heavy	Medium brood of larvae all killed	Heavy brood of living new adults
168	Med.	Med.	Thick bark probable reason for survival of few larvae and 1 pupae under 9 sq.ft. of bark	Medium number living pupae and new adults
169	Med.	Heavy	Few living larvae and pupae in green patch at base and 1 larvae in crevice under thick bark at 4 ft.	Heavy brood of living pupae and new adults
170	Light	Light	Tree contained only light brood of which all were killed on the treated side	Living brood of pupae showed only normal mortality

Table I (Continued)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
171	Med.	Light	Presence of only dead brood indicates 100% control	Light brood living pupae and new adults
172	Light	Light	Light brood at time of spraying all killed by treatment	Few living larvae and new adults at base of tree indicate poor brood tree
173	Med.	Light	Medium brood of mature larvae entirely controlled by treatment	Light living brood of pupae and new adults showed only normal mortality
174	Med.	Light	All brood dead indicates treatment 100% effective	Only normal mortality noted in brood on untreated side
175	Med.	Heavy	Only 2 larvae and 1 pupae under thick bark survived of moderately abundant brood	Abundant living brood
176	Light	Med.	Light brood all dead indicates 100% control Woodpecker work may have increased effectiveness	Numerous living larvae, pupae, and new adults under 2 sq. ft. of bark
177	Light	Light	All of light brood apparently killed by control measures	Only light brood remaining -- most of it parasitized by Coeloides

Table I (Cont.)

SPRAYED JUNE 16, 1937 WITH FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
15	27.7	98.7	4	1.3	4.0	11.0	32.5	89.0

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
82	Light	Light	No notes	No notes
85	Light	Heavy	5 sq. ft. revealed 2 surviving larvae in green section of bark. Light brood on this side	Fairly heavy brood of larvae, pupae, and new adults under 3 sq. ft. of bark, all alive
92	Med.	Med.	2 sq. ft. revealed medium brood of nearly mature larvae controlled - 4 living larvae under thick, green bark	2 sq. ft. showed medium brood living larvae, pupae, and new adults
97	Heavy	Heavy	¼ sq. ft. revealed only 2 living larvae of heavy brood. Survival possibly result of insufficient treatment	2 sq. ft. showed heavy brood all stages living
110	Light	Light	Numerous deep grooves protected by thick bark probable cause of only 75% kill of brood	Light basal brood of all stages surviving
118	Light	Light	2 sq. ft. showed complete control of nearly mature larvae killed by treatment - thin bark likely aided control	2 sq. ft. revealed light brood of living new adults. Thin bark, woodpecker work, and excessive drying resulted in small brood
121	Light	Heavy	1½ sq. ft. revealed complete control of light brood. Ips sp. attacked subsequent to spraying	1 sq. ft. revealed 1 pupae and 24 new adults on one sq. ft. of bark. Little recent mortality
123	Heavy	Med.	1½ sq. ft. failed to show any living brood in spite of deep creases, thick bark, and very moist condition	1 sq. ft. revealed 1 pupae, 15 new adults, and no recent mortality

Table I (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
130	Light	Heavy	2 sq. ft. revealed none of light brood living	1.5 sq. ft. revealed heavy living brood in base
131	Med.	Heavy	1 sq. ft. showed 2 living larvae under wet bark over ½" thick at base	½ sq. ft. bark at base revealed 12 living new adults
137	Light	Med.	1.5 sq. ft. revealed light larval and pupal brood dead on treated side	1 sq. ft. bark revealed 15 living new adults and 3 pupae. Secondaries very abundant
145	Heavy	Heavy	1.5 sq. ft. showed only 1 larva and 3 pupae under spot of very thick bark. Rest of treated area showed excellent control	2 sq. ft. revealed only a few living pupae and new adults due to woodpeckers and Coeloides
146	Light	Heavy	3 sq. ft. revealed no living insects, only light dead larval brood. Ips sp. attack after treating	2.5 sq. ft. showed heavy living brood in all stages of development
159	Heavy	Heavy	3 sq. ft. showed only 4 living larvae under thick bark at the base--heavy brood killed	Abundant brood in all stages of development over entire untreated half of tree to 4.5 feet living
160	Light	Heavy	2.5 sq. ft. revealed 3 living larvae in base of tree under moist bark--remaining light brood controlled	3 sq. ft. revealed abundant living brood in all stages at base, to sparse, highly parasitized brood above

Survival on treated side almost entirely confined to thick bark, wet sections, or green areas, usually at base of tree. Living brood largely confined to base of tree, only about 30% of observed brood being alive at 6 feet. Winter kill or other factor apparently responsible for high mortality.

Table I (Cont.)

SPRAYED JUNE 23, 1937 WITH FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
18	19.1	93.6	1.3	6.2	1.7	11.3	13.2	88.7

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
76	Heavy	Heavy	1 sq. ft. showed 28 dead larvae and pupae, 2 pupae and 2 new adults living--the living insects under thick bark	1 sq. ft. revealed 1 larva, 4 pupae, and 16 new adults living and no recent mortality
80	Heavy	Heavy	2 sq. ft. revealed 14 dead larvae and 2 living pupae--the latter under very thick bark over crease in bark	½ sq. ft. yielded 14 new adults under very tight, dry bark
91	Light	Light	1 sq. ft. showed 6 dead larvae and 2 dead new adults. Poor brood tree	1 sq. ft. revealed very light brood of only 2 new adults--no recent mortality
94	Light	Med.	2 sq. ft. revealed only 4 larvae, all dead	1½ sq. ft. showed only medium brood and no recent mortality
100	Med.	Light	½ sq. ft. showed complete control of medium larval and pupal brood	1 sq. ft. yielded only 3 living new adults--light brood had been controlled by parasites, predators, and dryness
111	Heavy	Heavy	1 sq. ft. showed 15 larvae and 2 pupae, all dead	1½ sq. ft. showed heavy living brood--35 new adults and 6 pupae. No recent mortality
126	Light	Light	1 sq. ft. revealed only 3 living new adults under thick bark. Survival possibly due to insufficient oil	3/4 sq. ft. gave light living brood of new adults

Table I (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
138	Light	Light	1½ sq. ft. showed only 1 pupae living of light brood	1 sq. ft. at base showed only scattered living new adults
149	Light	Med.	2 sq. ft. at base failed to show any survivors under thin bark	1 sq. ft. showed a medium brood heavily parasitized by Coeloides, leaving only few living pupae and new adults
153	Med.	Med.	2 sq. ft. showed dead brood even at base and in deep crevices	2 sq. ft. revealed scattered living larvae, pupae, and new adults
161	Light	Light	4 sq. ft. revealed all brood dead but 1 larvae--no explanation for that except poor treatment	4 sq. ft. revealed only light brood, much parasitism and woodpecker work
186	Light	Light	1.5 sq. ft. revealed very light brood of dead larvae, chiefly at extreme base	1 sq. ft. showed light brood of living new adults--no recent mortality
192	Light	Heavy	3.5 sq. ft. revealed 100% control of light brood	2 sq. ft. revealed 1 larva, 2 pupae, and 25 new adults living--very little recent mortality
202	Light	Light	1 sq. ft. showed light brood all killed	1 sq. ft. revealed 2 living new adults-- no recent mortality
206	Heavy	Heavy	.5 sq. ft. showed heavy brood of 29 larvae all dead	.75 sq. ft. revealed 33 new adults up to 2 feet on tree--no recent mortality
152	Med.	Heavy	1.5 sq. ft. showed all brood dead, 25% killed by Coeloides, rest by treatment	1.5 sq. ft. showed heavy brood heavily parasitized by Coeloides killing about 90% of brood
198	Light	Light	1.5 sq. ft. revealed 100% control	1.5 sq. ft. showed one Coeloides under thin bark
205	Med.	Light	.75 sq. ft. revealed 25 dead larvae--100% control	.75 sq. ft. showed 3 living new adults and 1 larva under thick bark--no recent mortality

Table I (Cont.)

SPRAYED JULY 8, 1937 WITH FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
10	10	100	-	-	1.2	14.3	7.2	85.7

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
233	Med.	Heavy	3/4 sq. ft. showed 7 larvae, 5 pupae, and 3 new adults, all dead--brood medium	3/4 sq. ft. showed 2 larvae, 15, new adults, 2 pupae. Heavy woodpecker work
234	Light	Light	1 sq. ft. revealed 6 larvae and 1 new adult all dead	3/4 sq. ft. revealed 1 pupae, 3 new adults living and 3 dead larvae--no apparent reason for recent death of larvae
235	Heavy	Heavy	3/4 sq. ft. showed 8 larvae and 12 dead Coeloides sp.	1 sq. ft. revealed 1 pupae and 15 new adults
236	Heavy	Med.	2 sq. ft. revealed 11 larvae, 5 pupae, and 4 new adults all dead	1 sq. ft. revealed 7 living new adults-- no recent mortality
237	Heavy	Heavy	2 sq. ft. revealed 21 pupae, 12 new adults all dead--brood dead even under 3/8 inch bark	2 sq. ft. showed 2 pupae, 35 new adults, all living--no recent mortality
238	Light	Light	1½ sq. ft. revealed no living brood--control occurred in pupal and new adult stages	1 sq. ft. revealed no living brood--no recent mortality
239	Med.	Heavy	Dead brood numbered 2 larvae and 3 new adults living brood of 4 pupae and 1 larvae found control only partial due to thick bark	1 sq. ft. revealed 28 larvae and 12 pupae living--12 of the larvae from overwintering parent adults.
240	Light	Med.	1 sq. ft. revealed complete control of light new adult brood	1 sq. ft. uncovered 10 living new adults-- no recent mortality

Table I (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side (1)	Untreated side
241	Light	Light	1 sq. ft. examined--no survivors	1 sq. ft. examined--no living brood
242	Light	Light	2.5 sq. ft. revealed 3 larvae and 3 new adults dead--treatment successful even under 3/8" bark	1½ sq. ft. revealed no living brood

(1) Trees 233-237 were treated on the north side, 238-242 on the south side.

Inspection of the tables shows little difference in the effect of treating at four different times. Apparently there are times during the year when the lethal oil acts quite rapidly, as only 12 and 13 days elapsed between treatment and examination of the last trees to be treated with this formula. The average degree of control was nearly 100 percent, with only an occasional unaccountably surviving insect. In general the survivors were present only under what is considered very thick lodgepole pine bark or under wet or green areas. As the oil gives very uncertain results where bark is more than one-half inch thick, it is very fortunate that such bark is found on only a few very large trees. The occasional insects for whose survival no reason is apparent were probably under an area of bark too lightly sprayed, or else were highly resistant to poisoning.

The insects surviving under lightly sprayed areas of bark indicate the necessity for thorough spraying, especially those trees with part or all of the bole covered with thick bark.

With the 1937 treatments confined to the base of the tree, where resistance to control by lethal oils is probably the greatest of any area on the tree, it may be reasonably expected that the data given in all tables will give a conservative index of the effectiveness of the treatment.

To secure an indication of the brood present in the treated trees at the time of treatment and in untreated trees at the time they were examined, 15 check trees were examined near the base on the north and south sides. Brood development data at the time of treating

are shown in table II under date of June 18, 1937. No extensive examination was made at that time, as it would have made a second examination of approximately the same area in these trees impossible. The second examination, which was both intensive and extensive, was made between July 12 and 21, 1937. The data for that period are also shown in table II under the period heading.

Table II

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE
CHECK TREES EXAMINED JUNE 18, 1937

Data from Intensive Examination of Base of Check Trees

Number of trees examined	Brood on north side: Dead: Per sq. ft.	Brood on north side: Dead: Percent of total on side	Brood on north side: Living: Per sq. ft.	Brood on north side: Living: Percent of total on side	Brood on south side: Dead: Per sq. ft.	Brood on south side: Dead: Percent of total on side	Brood on south side: Living: Per sq. ft.	Brood on south side: Living: Percent of total on side
15	6.2	23	20.7	77	10.3	19.5	42.5	80.5
EXAMINED JULY 12-31, 1937								
14	.7	6.3	10.6	93.7	.7	4.5	15.8	95.5

Notes from Extensive Examination

Tree no.	Amount of brood: North side	Amount of brood: South side	North side	South side
1	Light	Light	½ sq. ft. showed a few larvae from 1937-laid eggs	½ sq. ft. showed light brood of new adults
2	Med.	Heavy	No data	Larvae probably from eggs laid in 1937
3	Light	Light	2 sq. ft. showed no living brood, all having been killed by Coeloides sp.	¾ sq. ft. showed 2 larvae, 1 pupa, and 1 new adult
4	Light	Med.	Light surviving brood in all stages of development	Heavy living brood at base, light above 2 feet
5	Light	Light	1½ sq. ft. showed light living brood of pupae and new adults mainly in basal foot	¾ sq. ft. showed 2 larvae and 5 new adults, with some recent mortality in mature larval stages
6	Light	Light	Chiefly only secondaries present	Light brood living
7	Light	Light	No notes	No notes
9	Light	Light	1 sq. ft. showed very light brood of pupae and new adults	1 sq. ft. showed very light brood of pupae and new adults

Table II (Cont.)

Tree no.	Amount of brood: North side	Amount of brood: South side	Notes from Extensive Examination: North side	Notes from Extensive Examination: South side
10	Light	Light	Light brood surviving, chiefly new adults in base	Light brood surviving, chiefly new adults in base
11	Light	Light	½ sq. ft. showed 5 young larvae under very moist bark--side over ½ green	1 sq. ft. showed 4 young larvae--few egg galleries
12	Heavy	Heavy	1½ sq. ft. showed 22 larvae, 3 pupae, and 13 new adults--larvae chiefly from overwintering parent adults	½ sq. ft. showed 1 larva, 1 pupa, and 18 new adults--a heavy brood--little mortality of recent origin on either side at base
13	Med.	Light	½ sq. ft. showed 2 larvae, 3 pupae, and 8 new adults. Most brood hadn't advanced beyond egg stage	1 sq. ft. yielded 2 new adults
14	Med.	Light	1 sq. ft. yielded 1 pupa, 6 new adults near tree base. No recent mortality	1 sq. ft. yielded 1 pupa, 6 new adults. No recent mortality
15	Med.	Med.	3/4 sq. ft. yielded medium brood in all stages of development	½ sq. ft. yielded medium brood in all stages of development

A study of the survival on the treated sides compared with the same untreated side of the check trees clearly indicates the effectiveness of spraying with Formula A. However, for a more condensed comparison of the results obtained, table III has been prepared. The decided contrasts in survival for the same side on treated and untreated areas are clearly seen in the data presented. For the first three sprayings only about 1.5 percent of the brood present at the time of treating survived and probably emerged from the treated areas. In contrast, 77 percent of the brood was alive on similar areas on the untreated trees. For the late treatment the intensive examination revealed no survival, and the extensive examination showed only five living insects over a large area examined. In contrast, nearly 94 percent of the brood was found alive on the same side in the untreated trees.

From the survival observed under very thick, wet, or green bark it seems unlikely that complete control can be expected with this formula, but control is so near complete as to make its use feasible as a control measure.

Table III

SUMMARY OF BROOD MORTALITY IN TREES TREATED
WITH FORMULA A AND IN CHECK TREES
TARGHEE FOREST - 1937

Treated Side of Sprayed Trees and North Side of Check Trees					
Date treated	June 10	June 16	June 23	Average of previous tree treatments	July 8
Total brood per square foot	36.2	28.7 b	20.4	28.4	10
Percent of total brood					
Dead	100	98.7	93.8	98.2	100
Living	-	1.3	6.2	1.8	-

Check Trees		
Date examined	June 18	July 12-21
Total brood per square foot	26.9	11.3
Percent of total brood		
Dead	23	6.3
Living	77	93.7

Formula B

This formula consisted of the following materials:

Light stove oil	---	3 parts
Heavy stove oil	---	1 part
Naphthalene	---	1 lb. per gallon of oil

Two tests were made of this formula, one on June 24, 1937 and the second on July 9, 1937. Good control was secured in both cases, with the data from the June 24 treatment showing the better results. However, the combined data from both intensive and extensive examinations for both times of treating indicate less than two percent survival. On that basis there is little to choose between the effectiveness of Formulas A and B.

The data for both intensive and extensive examinations are shown in the two parts of table IV.

Table IV

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL---SPRAYED JUNE 24, 1937 WITH FORMULA B

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
18	26.2	98.3	.4	1.7	2.5	14.3	15.2	85.7

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
77	Med.	Heavy	1.5 sq. ft. uncovered fairly heavy brood in larval stage, all dead	1.5 sq. ft. showed heavy brood in all stages of development
84	Med.	Light	2 sq. ft. revealed fairly heavy brood in larval stage, all dead	1.5 sq. ft. revealed very light brood in all stages of development
89	Med.	Med.	2.5 sq. ft. showed fairly heavy brood, mature larvae, all dead	1.5 sq. ft. uncovered 2 larvae, 2 pupae, and 8 new adults below 2 ft. in wet bark. Heavy parasitism by Coeloides
93	Light	Light	1 sq. ft. revealed light brood, all killed except 1 larva apparently under lightly sprayed spot	1 sq. ft. revealed light living brood
95	Med.	Light	2.5 sq. ft. uncovered medium brood either killed by treatment or parasitized	2 sq. ft. showed only light brood had been present--all died as small larvae or were parasitized.
101	Med.	Light	1 sq. ft. showed complete control of larvae and pupae	1 sq. ft. showed very light brood new adults and pupae
107	Heavy	Heavy	.5 sq. ft. uncovered 3 living new adults and much dead brood--no apparent reason for survival	All brood dead on untreated 3 sides

Table IV (Cont.)

Notes from Extensive Examination

Tree No.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
114	Light	Med.	1.5 sq. ft. revealed light brood of dead larvae, except for 1 larvae under area probably too lightly sprayed	1 sq. ft. showed medium brood in pupal and new adult stages
124	Light	Light	1.5 sq. ft. revealed light brood all dead	1 sq. ft. revealed very light brood of living larvae, pupae, and new adults
133	Med.	Med.	1 sq. ft. revealed 1 living larva under upper end of green strip of thick bark	1 sq. ft. uncovered 1 larva and 7 new adults living
134	Light	Med.	1.5 sq. ft. showed light, dead larval brood	1 sq. ft. showed medium living brood in all stages
143	Light	Med.	1 sq. ft. uncovered light, dead brood of larvae	1 sq. ft. revealed medium brood living new adults and pupae
151	Heavy	Heavy	2.5 sq. ft. showed 2 larvae and 1 pupa living of heavy brood. Survival under 3-inch bark adjoining green strip	1.5 sq. ft. uncovered 17 new adults, dead
179	Light	Light	1.5 sq. ft. revealed light brood, all dead	1.5 sq. ft. revealed very light living brood in all stages
161	Light	Heavy	1.5 sq. ft. revealed light brood, all killed in spite of green, wet bark	Heavy surviving brood
162	Med.	Med.	1.5 sq. ft. uncovered medium larval brood under very thick bark--1 new adult living under $\frac{1}{8}$" bark	2 sq. ft. revealed heavy, living brood on SE side, rest a very light brood
193	Light	Light	1 sq. ft. showed light, dead larval brood	1 sq. ft. showed light brood living of pupae and new adults
194	Light	Light	1.5 sq. ft. revealed light, dead larval brood	1 sq. ft. uncovered light, living larval, pupal, and new adult brood

Table IV (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA B

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed (1)	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
10	15.2	90.5	1.6	9.5	.4	2.6	14.8	97.4

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
53	Heavy	Heavy	1 sq. ft. showed 6 larvae, 10 pupae, and 12 new adults, all dead	1 sq. ft. revealed a heavy living brood of 7 larvae, 3 pupae and 15 new adults—no recent mortality
108	Med.	Light	1 sq. ft. revealed 6 new adults and 3 pupae dead in deep creases and 1 living new adult under about .35 bark thickness	1 sq. ft. showed 1 larva, and 2 new adults only light brood had hatched and mortality in early stages
117	Light	Light	1.5 sq. ft. showed no brood--poor tree for treatment	.75 sq. ft. revealed no living brood--mortality occurred in small larval stage
120	Light	Light	.75 sq. ft. reveals no surviving brood	Light brood had reached new adult stage, then died probably as result of extremely dry bark
135	Med.	Light	1 sq. ft. revealed 2 living larvae in a moist spot under nearly .5 inch bark	Scattered light brood all killed in new adult stage
144	Heavy	Heavy	2 sq. ft. showed 6 larvae, 1 pupa, and 5 new adults dead and 1 larva living under ⅛ inch bark	1.5 sq. ft. revealed 15 living new adults and no recent mortality
154	Light	Light	1.5 sq. ft. revealed perfect control	.75 sq. ft. revealed light brood 0-⅛ larvae

Table IV (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
155	Heavy	Heavy	1.5 sq. ft. revealed dead brood of 16 new adults, 2 pupae, and 11 larvae	6 larvae, 1 pupa, 30 new adults on untreated side, living. No recent mortality
191	Light	Light	2 sq. ft. showed 8 larvae and 1 pupa dead	1.5 sq. ft. revealed no living brood, only parasites
199	Med.	Med.	1 sq. ft. showed complete mortality	1 sq. ft. showed medium living brood with very little mortality

(1) North side 83-135; south side 144-199.

Formula C

This formula consisted of the following materials:

Light stove oil	---	4 parts
Orthene	---	1 part

This mixture also gave excellent control. The trees treated on June 23 showed only 1.4 percent survival on the treated side from the intensive examination data. The extensive examination data indicated an even higher percentage of control, and the average of the two shows about one percent survival.

Results from the July 9 treatment were not as good, but notes from the extensive examination indicate a higher average of trees with thick bark, wet bark, and green areas than in the other series so far discussed. The data from the extensive examination show only about 6 percent survival, and an average of both intensive and extensive shows less than 10 percent. If only a normal number of resistant areas on the treated trees were present in this group, it is believed the survival would be found to be less than 5 percent and place the group practically on a par in effectiveness with those treated with Formulas A and B. The data secured are shown in the two parts of table V.

Table V

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 23, 1937 WITH FORMULA C

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
18	62	98.6	.9	1.4	2.9	10.4	24.9	89.6

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
78	Light	Light	1.5 sq. ft. showed only 1 larva living in a deep crease under thick bark--survival in sample unaccountable	1 sq. ft. showed 2 larvae and 3 new adults
86	Light	Light	2.5 sq. ft. revealed very light dead brood except 3 under thick bark	light brood living in all stages of development, 50% killed by Coeloides
98	Light	Light	1 sq. ft. revealed complete control	2 sq. ft. revealed 5 living new adults
102	Med.	Light	1.5 sq. ft. --brood of dead larvae in base	1 sq. ft. uncovered a light brood of living new adults in base of tree
104	Heavy	Light	1 sq. ft. revealed 1 pupa, 2 new adults under thick-barked green spot	1 sq. ft. yielded 3 larvae, 4 pupae, and 2 new adults
112	Med.	Med.	2 sq. ft. showed no survivors even of larvae from eggs laid in 1937 by overwintering parent adults	1 sq. ft. showed 1 larva, 1 pupa, 7 new adults living--considerable recent mortality with no indication of reason
119	Heavy	Heavy	2 sq. ft. revealed 3 larvae living under bark as much as 3/4 inch thick--much brood developed to new adults before controlled	.75 sq. ft. revealed 16 new adults--bark over $\frac{1}{2}$ inch thick in places

Table V (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side (1)	Untreated side
128	Heavy	Heavy	1.5 sq. ft. revealed heavy brood killed even under bark 3/8 inch thick	1.5 sq. ft. uncovered heavy brood, all stages.
139	Heavy	Med.	1 sq. ft. showed 2 larvae, 1 pupa, 2 new adults living under wet portions of bark	1 sq. ft. uncovered 1 pupa, 15 new adults living--no recent mortality
140	Light	Light	2 sq. ft. showed 100% control light larval brood	.75 sq. ft. revealed very light brood of living larvae, pupae and new adults
156	Heavy	Heavy	1.5 sq. ft. revealed 1 larva living for which no reason can be given	1 sq. ft. showed 16 new adults living--heavy parasitism
157	Light	Light	1 sq. ft. uncovered light brood of larvae, pupae, and new adults all dead, except 1 pupa under thick piece of bark	1.5 sq. ft. showed light brood of living new adults
184	Med.	Med.	1 sq. ft. showed no survivors of the medium brood	.5 sq. ft. showed medium brood alive--no recent mortality
200	Light	Light	.5 sq. ft. revealed no survivors	.75 sq. ft. uncovered 12 larvae and 8 pupae alive--larvae from eggs laid this spring by overwintering parent adults
204	Med.	Light	1 sq. ft. uncovered 15 dead larvae	1.5 sq. ft. revealed no brood
150	Heavy	Heavy	2 sq. ft. showed 100% mortality of heavy brood of all developmental stages	1.5 sq. ft. showed heavy survival, chiefly new adults
183	Med.	Med.	2 sq. ft. revealed no survivors	.5 sq. ft. showed medium brood in larvae, pupae, and new adults
195	Med.	Heavy	1 sq. ft. showed no survivors	1 sq. ft. revealed 17 new adults alive--heavy woodpecker work and thick bark

(1) North side on trees 78-204; south side on 150, 183, 195.

Table V (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA C

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. foot	Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
10	6.8	85.0	1.2	15	2.4	15.4	13.2	84.6

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Untreated side	(1) Treated side	Untreated side
246	Light	Light	1.5 sq. ft. revealed light brood of 7 larvae and 2 pupae dead and 1 larva living--no apparent reason for survival	3 sq. ft. showed light brood of new adults--no recent mortality
247	Light	Med.	.5 sq. ft. showed no survivors of light brood of new adults	1 sq. ft. revealed medium brood of new adults living--no recent mortality
253	Light	Light	2.5 sq. ft. uncovered 2 larvae, 1 pupa, and 2 new adults, all dead--poor brood tree	3 sq. ft. revealed no brood--secondaries took over the side
254	Light	Light	1.5 sq. ft. showed light brood of 3 larvae and 4 pupae all dead	2 sq. ft. showed no brood--bark tight and dry
255	Heavy	Heavy	2 sq. ft. revealed 3 living larvae under wet portion--heavy control even in wet portion	2 sq. ft. revealed 6 larvae, 4 pupae, and 31 new adults all living--no recent mortality
248	Med.	Light	2 sq. ft. uncovered 6 larvae, 4 pupae, and 7 new adults all dead	3 sq. ft. showed light brood of 6 new adults 2 pupae, and 4 larvae living
249	Heavy	Light	3 sq. ft. revealed 19 new adults and 9 pupae all dead	.5 sq. ft. revealed 5 new adults living--no recent mortality

Table V (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
250	Light	Light	1.5 sq. ft. showed light brood, all dead	.5 sq. ft. uncovered light brood of larvae, pupae, and new adults living
251	Med.	Med.	1.5 sq. ft. revealed 2 living new adults of medium brood controlled--no apparent reason for survival	.75 sq. ft. a medium brood of living new adults showed no recent mortality
252	Med.	Light	1.5 sq. ft. uncovered 1 living new adult of a medium brood	2 sq. ft. uncovered light living brood of larvae, pupae, and new adults

(1) North side for 246-7 and 253-5; south side 248-252.

Formula D

This formula consisted of the following materials:

Sodium thiocyanate	---	one pound
Water	---	one gallon

The results from spraying with this mixture indicate it is ineffective as a control means. Data from the treated and untreated sides show there is a greater percentage of survival on the treated than on the untreated sides.

The data are shown in table VI.

Table VI

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL LIQUID
SPRAYED JUNE 25, 1937 WITH FORMULA D

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
12	2.6	17.3	12.3	82.7	7	23.6	22.7	76.4

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Untreated side	Treated side	Untreated side
79	-	-	Material seems to have had corrosive effect on bark--no apparent control	
87	-	-	No recent mortality--even secondaries alive	
88	-	-	Discolored bark but no evidence of control	
103	-	-	Brood alive from eggs laid by overwintering parent adult	
115	-	-	2 sq. ft. showed no control	2 sq. ft. showed no living brood
116	-	-	2 sq. ft. showed 3 larvae dead and 4 pupae alive	2 sq. ft. showed no brood
132	Heavy	Heavy	1 sq. ft. revealed heavy brood living pupae and new adults--recent mortality of 2 larvae	1.5 sq. ft. revealed heavy brood pupae and new adults
141	-	-	1 sq. ft. uncovered 1 larva, and 1 new adult treatment ineffective	1 sq. ft. showed 1 new adult living
159	-	-	1 sq. ft. showed 1 larva, 2 pupae, and 3 new adults all living--no recent mortality--treatment a failure	

Table VI (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
196	-	-	1 sq. ft. uncovered 1 larva, 7 new adults--slight recent mortality--treatment ineffective	.5 sq. ft. uncovered 2 larvae and 15 new adults
197	-	-	.25 sq. ft. revealed 11 new adults--no apparent recent mortality	.5 sq. ft. revealed 1 pupa and 5 new adults
211	-	-	Living brood of 15 new adults and 3 dead larvae	2 sq. ft. showed 3 pupae and 10 new adults living and 1 dead larva

Formula E

This formula consisted of the following materials:

Mineral spirits	---	3 parts
Orthene	---	1 part

Control secured from this oil was good, but not as high as with Formulas A, B, and C. It is felt that this oil has shown too little effectiveness to warrant further consideration.

The data secured are shown in table VII.

Table VII

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 25, 1937 WITH FORMULA E

Data from Intensive Examination of base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
10	20	75.8	6.4	24.2	1.6	7.8	18.8	92.2

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
203	Med.	Heavy	.5 sq. ft. yielded 4 larvae living--control had occurred in mature larval and pupal stages	.25 sq. ft. showed 30 new adults living and 2 larvae and 1 pupa dead
224	Light	Light	2 sq. ft. showed only 5 dead larvae--no living brood	1.5 sq. ft. revealed 5 new adults living and 2 dead larvae
225	Med.	Heavy	1.5 sq. ft. revealed 49 larvae living under ½ inch thick green bark	.5 sq. ft. yielded 9 larvae, 5 pupae, and 75 new adults living
226	Med.	Heavy	3 sq. ft. yielded 10 larvae dead and 5 larvae living--the latter being protected by thick bark	2 sq. ft. showed 6 larvae, 3 pupae, and 20 new adults living--no recent mortality
227	Med.	Med.	2 sq. ft. showed 1 new adult living	1.5 sq. ft. revealed 18 larvae, 2 pupae, and 8 new adults--no recent mortality except by parasites
228	Light	Light	1.5 sq. ft. revealed no living brood	Light brood
229	Light	Heavy	1 sq. ft. yielded 1 larva and 1 new adult	.75 sq. ft. yielded heavy brood which showed little recent mortality

Table VII (Cont.)

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Notes from Extensive Examination: Treated side	Notes from Extensive Examination: Untreated side
230	Light	Light	1 sq. ft. showed 1 larva, 2 pupae living and 8 larvae dead	3 sq. ft. showed 3 new adults living--no recent mortality
231	Light	Light	3 sq. ft. revealed 6 larvae dead and 2 pupae living--no apparent reason for survival	1 sq. ft. revealed 1 larva, 4 pupae and 5 new adults living
232	Light	Light	1.5 sq. ft. yielded 3 larvae and 1 new adult living in very moist place	1 sq. ft. uncovered 4 new adults alive--some recent mortality

Formula F

This formula consisted only of light stove oil which was tested to determine if it had any lethal effect on bark beetle broods. The data from both intensive and extensive examinations indicate the oil has considerable lethal effect even without the addition of other materials, but does not give sufficient control to warrant its use without the addition of a more lethal agent.

Table VIII presents the data secured.

Table VIII

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 25, 1937 WITH FORMULA F

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
11	12.73	60.4	8.36	39.6	-	-	24.36	100

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
81	Light	Med.	2 sq. ft. showed a light brood with about 25% survival--treatment apparently ineffective	1.5 sq. ft. revealed medium brood in all stages of development with considerable recent mortality in larval stage
90	Light	Light	4 sq. ft. revealed no brood	3 sq. ft. showed 5 pupae living--most of side green
105	Light	Light	2 sq. ft. uncovered 6 larvae dead	1.5 sq. ft. uncovered 7 new adults alive
106	Light	Med.	2 sq. ft. yielded light brood of larvae, pupae, and new adults, half of which were living--treatment apparently ineffective	2 sq. ft. revealed medium brood of living new adults and pupae--no recent mortality
122	Med.	Med.	2 sq. ft. showed 15 new adults and 1 pupa living and 3 larvae dead	1 sq. ft. yielded 12 new adults living--no recent mortality
136	Light	Med.	1.5 sq. ft. revealed 1 larva and 1 new adult living--no apparent reason for larva's survival--new adult near edge of treated area	1 sq. ft. showed 1 larva, 3 pupae, and 14 new adults living--no recent mortality
142	Heavy	Heavy	2 sq. ft. uncovered 4 larvae, 3 pupae, and 2 new adults living and 7 larvae dead--treatment unsuccessful	3 sq. ft. showed heavy living brood in all developmental stages

Table VIII (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
180	Light	Med.	1 sq. ft. showed 6 larvae, 2 pupae, and 5 new adults under thick, moist bark--treatment only partly effective	.5 sq. ft. revealed 11 larvae and 5 new adults living
187	Light	Light	.5 sq. ft. yielded 8 larvae living from eggs laid in 1937--no recent mortality--treatment ineffective	.5 sq. ft. yielded 1 larva and 2 pupa living
212	Med.	Heavy	2 sq. ft. uncovered 2 larvae and one new adult living and 5 larvae, 3 pupae, and 6 new adults dead--treatment partly effective	Heavy living brood in all stages of development
215	Med.	Med.	1 sq. ft. revealed 1 larva and 1 new adult living, indicating good but not perfect control	1 sq. ft. showed 4 larvae, 2 pupae, and 9 new adults living--little recent mortality

(1) North side on all but 212 and 215, which were on south side.

Formula G

The materials used in this formula were the following:

Kerosene	---	3 parts
Orthene	---	1 part

The objective sought with kerosene as the carrier of the lethal agent was to find a material more readily penetrating bark than fuel oil. Intensive examination of the few trees sprayed showed perfect control, but the extensive examination revealed a few living insects and reduced control to about 97 percent. Although giving control almost equal to that secured with fuel oil as the penetrant, kerosene is so much more expensive that the former is to be preferred.

Data for the experiment are shown in table IX.

Table IX

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 25, 1937 WITH FORMULA G

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
5	35.2	100	-	-	-	-	14.4	100

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
213	Light	Light	1.5 sq. ft. revealed 1 larva and 1 pupa living--moist bark may account for survival	1.5 sq. ft. showed 8 larvae and 5 new adults living--little recent mortality
216	Heavy	Light	2 sq. ft. showed 46 larvae dead--treatment very good	1.5 sq. ft. revealed 4 larvae, 1 pupa, and 6 new adults all living
217	Heavy	Light	2 sq. ft. uncovered 43 larvae, dead	1.5 sq. ft. uncovered 10 new adults living --no recent mortality
218	Med.	Heavy	1 sq. ft. showed 3 larvae, 1 pupa, and 4 new adults alive, indicating good but not perfect control--wet bark responsible	1 sq. ft. yielded 1 larva, 3 pupae and 15 new adults
219	Heavy	Light	1.5 sq. ft. revealed 18 larvae, dead	1 sq. ft. showed 2 larvae and 8 new adults --no recent mortality

Formula H

The materials in the formula were as follows:

Stoddard solvent	---	3 parts
Orthene	---	1 part

Again it was with the idea of finding a more efficient carrier of the lethal material that prompted the use of the Stoddard solvent. Indications from the extensive and intensive examinations were that from 6 to 10 percent of the brood had survived from this treatment. This degree of control was somewhat less than with some of the other formulae, and in addition is considerably more expensive. For the above reasons it is not as desirable as the mixtures in which fuel oil is the penetrant.

Table X shows the data.

Table X

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 25, 1937 WITH FORMULA H

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on Treated Side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side	Brood on Untreated Side: Dead: Per sq. ft.	Dead: Percent of total on side	Living: Per sq. ft.	Living: Percent of total on side
12	18.9	91.2	1.8	8.8	2.6	9.9	23.3	90.1

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
99	Light	Heavy	1.5 sq. ft. yielded 3 larvae and 2 pupae living, bark over survivors up to .3 inch and moist	1 pupa and 30 new adults indicates heavy brood--little recent mortality
109	Heavy	Med.	1 sq. ft. showed 34 larvae, 1 pupa, dead	.5 sq. ft. yielded 9 larvae and 13 new adults --little recent mortality
113	Light	Light	2 sq. ft. uncovered 1 larva under wet spot in bark	1 sq. ft. showed 1 pupa, 2 new adults
156	Light	Light	2.5 sq. ft. revealed 1 pupa under very thick bark in furrow of tree	2 sq. ft. uncovered light brood in all stages of development
162	Light	Light	.5 sq. ft. showed no surviving brood	.5 sq. ft. yielded 3 new adults living--no recent mortality
176	Light	Light	2 sq. ft. showed 11 dead larvae, none living	1 sq. ft. showed 2 new adults living--no recent mortality
185	Light	Light	1.5 sq. ft. revealed 15 dead larvae	1 sq. ft. uncovered 7 new adults living--no recent mortality

Table X (Cont.)

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Notes from Extensive Examination (1): Treated side	Notes from Extensive Examination (1): Untreated side
207	Light	Med.	1.5 sq. ft. uncovered 9 larvae living from green area	.5 sq. ft. yielded 13 larvae, 5 pupae, and ¼ new adults living
208	Med.	Heavy	2 sq. ft. showed 3 larvae, 2 pupae, and 2 new adults surviving--treatment none too good	.5 sq. ft. uncovered 28 larvae and 2 new adults--larvae from this year's eggs
201	Light	Light	3.5 sq. ft. showed 21 larvae, 3 pupae and 1 new adult dead	2 sq. ft. revealed 15 larvae and 3 pupae living--no recent mortality
209	Med.	Heavy	1.5 sq. ft. revealed 6 pupae and 3 new adults, dead	1 sq. ft. revealed 20 new adults and 3 pupae living--no recent mortality

(1) North side except for 201 and 209, which are on south side.

Table X (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA H

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
10	16.4	89.1	2	10.9	2.8	33.3	5.6	66.7

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
125	Light	Light	1.5 sq. ft. showed 1 larva, 2 pupae, and 4 new adults, dead	3 sq. ft. revealed 3 new adults living
127	Light	Light	1 sq. ft. revealed no survivors of treatment	.75 sq. ft. uncovered 1 new adult living
147	Heavy	Light	1.5 sq. ft. yielded 1 new adult, 5 larvae; latter in deep crease	1 sq. ft. yielded light brood of new adults
148	Light	Light	1.5 sq. ft. showed 4 new adults, dead	1 sq. ft. yielded 3 new adults, living
188	Light	Light	1.5 sq. ft. revealed 3 new adults and 1 larva, dead	1.5 sq. ft. showed no brood
190	Med.	Heavy	1.5 sq. ft. yielded 8 larvae, 2 pupae, and 6 new adults, dead	2 sq. ft. revealed 47 new adults, living
214	Light	Light	1.5 sq. ft. showed 5 larvae, 2 pupae, and 2 new adults, dead	1.5 sq. ft. uncovered 22 larvae, dead
243	Light	Light	1 sq. ft. showed 1 new adult, living	1 sq. ft. revealed light, living brood in new adult stage

Table X (Cont.)

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	(1) Treated side	Untreated side
244	Light	Light	1.5 sq. ft. revealed 100 percent mortality of light brood	1 sq. ft. uncovered light, living brood in new adult stage
245	Light	Med.	2 sq. ft. uncovered only 6 dead larvae	2 sq. ft. yielded 15 new adults living--no recent mortality

(1) North side 125-188, south side 190-245.

Formula I

In this test orthene was used undiluted.

The objective of the experiment was to determine any variation that might exist in the effectiveness of orthene pure and orthene diluted with oils.

Both the intensive and extensive data show light survival on the treated side, indicating that pure orthene is no more effective than when in mixture with fuel oils.

The data are given in table XI.

Table XI

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH ETHAL OIL
JUNE 25, 1937 WITH FORMULA I

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side: Dead: Per sq. ft.	Brood on treated side: Dead: Percent of total on side	Brood on treated side: Living: Per sq. ft.	Brood on treated side: Living: Percent of total on side	Brood on untreated side: Dead: Per sq. ft.	Brood on untreated side: Dead: Percent of total on side	Brood on untreated side: Living: Per sq. ft.	Brood on untreated side: Living: Percent of total on side
5	32.8	97.6	.8	2.4	1.6	10.5	13.6	89.5

Notes from Extensive Examination

Tree no.	Amount of brood: Treated side	Amount of brood: Untreated side	Treated side	Untreated side
210	Med.	Med.	1 sq. ft. showed no surviving D.m. brood	.75 sq. ft. showed 2 larvae and 18 new adults, living--very little recent mortality
220	Light	Light	2 sq. ft. uncovered 12 larvae, dead	1 sq. ft. revealed only 4 new adults, living
221	Light	Med.	2 sq. ft. yielded 25 larvae dead	2.5 sq. ft. uncovered 6 larvae, 7 pupae, and 9 new adults living
222	Light	Light	1 sq. ft. showed 100% control of light brood	.5 sq. ft. showed 3 new adults alive and many Coeloides sp. parasites
223	Light	Light	1.5 sq. ft. revealed 13 larvae dead & living	1 sq. ft. revealed no brood

SUMMARY

During 1937 various mixtures of lethal oils and one aqueous solution were tested in the search for a spray which when applied to the bark of mountain-pine-beetle-infested lodgepole pine would kill the infesting brood.

A number of the formulae tested in 1937 gave excellent results, including A, B, C, E, G, H, and I. All but three of these mixtures, however, were too costly to be practical for general control.

On the basis of the 1937 and previous experiments, Formula A has given the most consistently favorable results. However, with both naphthalene and orthene in its composition, it is more expensive than those in which only orthene or naphthalene are mixed with the fuel oil.

The 1936 and 1937 experiments with fuel oil and orthene gave excellent results, but the orthene is more expensive than naphthalene, and being a liquid is not as readily adapted to field use as the crystalline naphthalene. Naphthalene, however, does not dissolve readily in fuel oil until the latter is heated to about 100°F, and the time and equipment needed for this heating probably places the formula comprising fuel oil and naphthalene practically on a par as to cost with the one containing fuel oil and orthene.

The desired 100 percent control has not been consistently obtained with any of the formulae. Green or partly green bark areas or areas

of bark having a high moisture content are usually those under which survival has been noted. It is believed that the more or less moisture-saturated condition of the bark prevents the absorption and penetration of the oils.

Although complete control was not realized with any of the formulae tested, such a high percentage of kill was obtained with mixtures of fuel oil and naphthalene or orthene, or both, that their use for bark beetle control in lodgepole pine seems quite feasible and warrants further tests with formulae A, B, and C.

Respectfully submitted,

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